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Spectroscopic Binaries Among λ Bootis-type Stars

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Abstract. The small group of λ Bootis stars comprises late B to early F-type stars, with moderate to extreme (up to a factor 100) surface under-abundances of most Fe-peak elements and solar abundances of lighter elements (C, N, O, and S). The main mechanisms responsible for this phenomenon are atmospheric diffusion, meridional mixing, and accretion of material from their surroundings. Especially spectroscopic binary (SB) systems with λ Bootis-type components are very important to investigate the evolutionary status and accretion process in more details. Because also δ Scuti type pulsation was found for several members, it gives the opportunity to use the tools of astroseismology for further investigations. We present the results of our long term efforts of detailed abundance analysis, orbital parameter estimation and photometric time series analysis for five well investigated SB systems.

Keywords. stars: chemically peculiar, delta Scuti, circumstellar matter, binaries: spectroscopic

1. Introduction

The small group of λ Bootis stars comprises late B to early F-type stars, with moderate to extreme (up to a factor 100) surface under-abundances of most Fe-peak elements and solar abundances of lighter elements (C, N, O, and S). Since they are found at ages up to 1 Gyr, they are excellent test laboratories for atmospheric processes in the context of stellar evolution. Our international working group has been investigating this star group for about 15 years in a joint effort to shed more light on its nature. Here, we present our results about the SB members.

2. Theories, planets and binary nature

Kamp & Paunzen (2002) and Martinez-Galarza *et al.* (2009) developed a model which is based on the interaction of the star with its local ISM environment. Different levels of under-abundance are produced by different amounts of accreted material relative to the photospheric mass. The small fraction of this star group is explained by the low probability of a star-cloud interaction and by the effects of meridional circulation, which

washes out any accretion pattern a few million years after the accretion has stopped. The behavior is suppressed in low temperature stars because of their more massive, difficult to contaminate convection zones. Strong stellar winds prevent the accretion of material for very hot stars. Naturally, both stars of a spectroscopic binary system (SB) pass through the same diffuse cloud. Binary systems with a “normal” and λ Bootis-type companion would rule out this scenario. It is, therefore, essential to study these systems in more detail.

HR 8799 is a λ Bootis, γ Doradus star (the only one known among this group) hosting a planetary system and a debris disk with two rings (Moya *et al.* 2010). Their conclusion is that there are no models with solar metallicity fulfilling the observations, since the stellar luminosity derived from the observations is smaller than any of the possible luminosities of models with solar metallicity. However, the light elements are solar which could lead to the scenario that the star accretes substantial amounts of left-over gas from planet formation at early stages, which would be depleted in metals, but not in C, N, O, and S.

3. The known SB λ Bootis type systems

Up to now, there are several “ λ Bootis-type” SB systems known: HD 64491, HD 84948, HD 111786, HD 141851, HD 171948, HD 174005, HD 193256/193281, HD 198160/1, and HD 210111. A detailed abundance analysis was done for HD 84948, HD 171948, and HD 210111 (Heiter 2002, Iliev *et al.* 2002, and Paunzen *et al.* 2002). From our extensive analysis of these SB systems, we conclude

- The ages vary from the zero-age to the terminal-age main sequence
- Both components always show the same λ Bootis-type abundance pattern
- The astroseismic results show, up to now, no differences to normal type δ Scuti stars
- The spacial kinematics are typical for Population I disk members
- For HD 210111, an IR excess was detected which is due to a circumstellar disk

Our current knowledge of the SB λ Bootis type systems is, therefore, consistent with the model of the strong interaction of the objects with their local ISM environment explaining the observed abundance pattern and their widely different evolutionary stages.

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